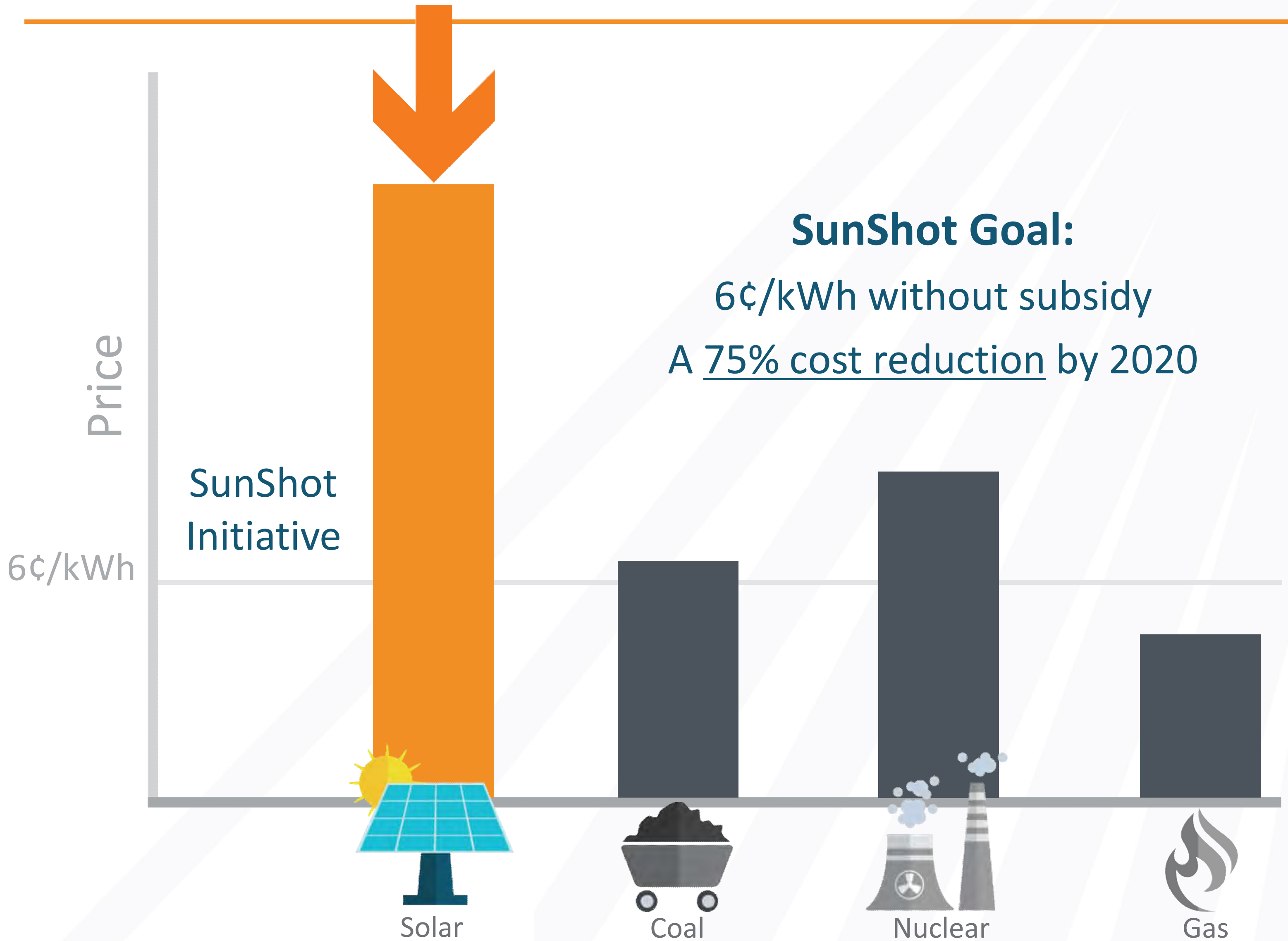
SunShot
U.S. Department of Energy

The Solar Energy Evolution and Diffusion Studies (SEEDS) Program

Dave Rench McCauley, Senior Program Associate
Contractor to Solar Energy Technologies Office
U.S. Department of Energy

SunShot Initiative

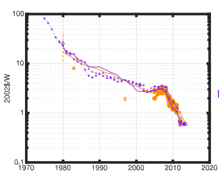


Solar Energy Evolution and Diffusion Studies (SEEDS)

Some tantalizing results

- **Did You Know?**

  - **Economic forces have been found to supplant environmental reasons** as the primary drivers of individual decisions to adopt solar



  - Also, **recent massive price drops in solar arrays are primarily due to investments in increased manufacturing plant sizes, not traditional R&D investments**
- SEEDS 2 uses this core knowledge and expands on it in two different directions: studying the **behavior of organizations** and studying the **behavior of individuals in the LMI community**

SEEDS – The Beginning (AKA 2013)

- Interdisciplinary team structures
- Academic work informing pilot projects
- How do technologies develop over time and why do people adopt those technologies?

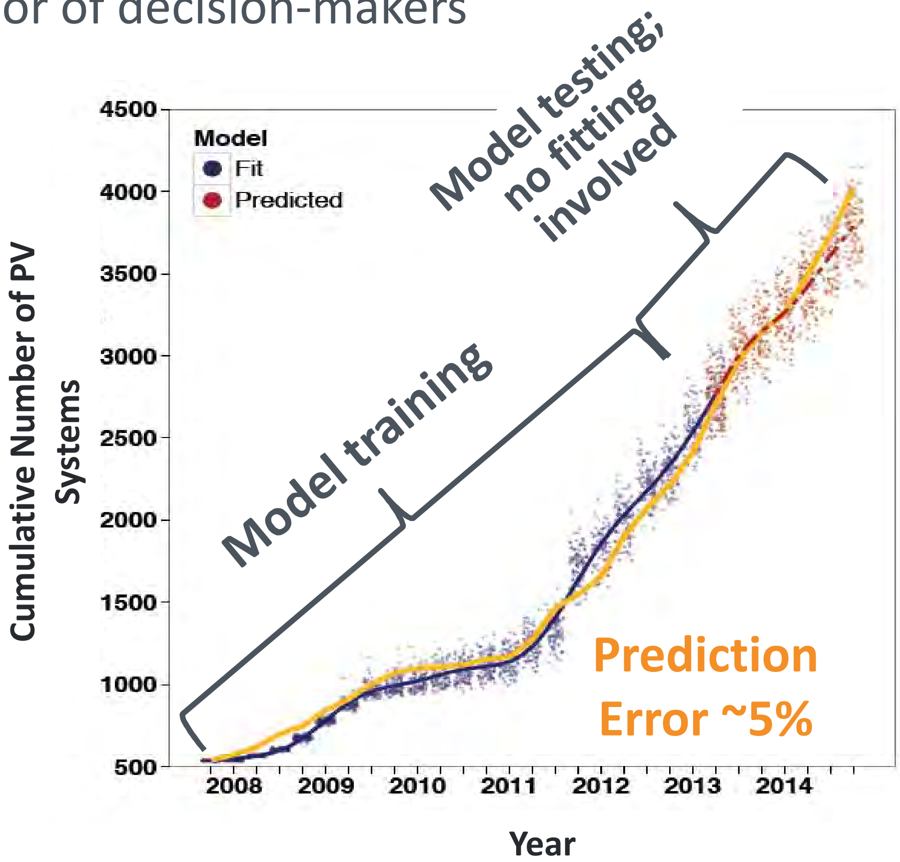
Academics

Practitioners

What Drives the Spatio-Temporal Patterns of Residential PV Diffusion?

PI: Varun Rai

- **The Goal:** study PV diffusion as an emergent system arising from the interactive behavior of decision-makers that are rationally-bounded



- Information: key to making solar attitudes = expected affordability

Understanding the Evolution of Customer Motivations and Adoption Barriers in Residential PV Markets

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

PI: Ben Sigrin

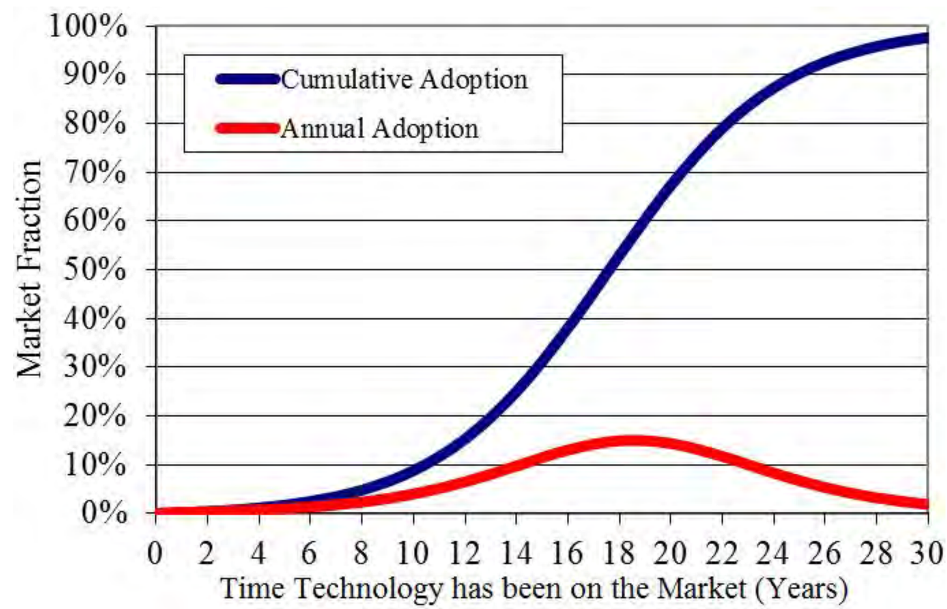
- **A Question:** what are the differences between "solar adopters" and "solar considerers" and how does one become the other? Also, is solar adoption typically a pre-meditated decision?

- **Methodology:**
  - ABM
  - Adopter, non-adopter, general population surveys
  - Email campaign pilots

- **The Results:**
  - **Only 11% of solar considerers decided to definitely not pursue solar** – installers take note!
  - Primarily *not* pre-meditated decision!
  - Email campaign: found **early/late-majority adopters respond to "monthly loss" framing**

Reasons for Considering Solar

- Environment Primarily: 3-5%
- Environment + Money: 33%
- Both, but Money over Environment: 39%
- Money and not Environment: 6%
- Opportunistic: ~20%



Promoting Solar Technology Diffusion Through Data-Driven Behavior Modeling

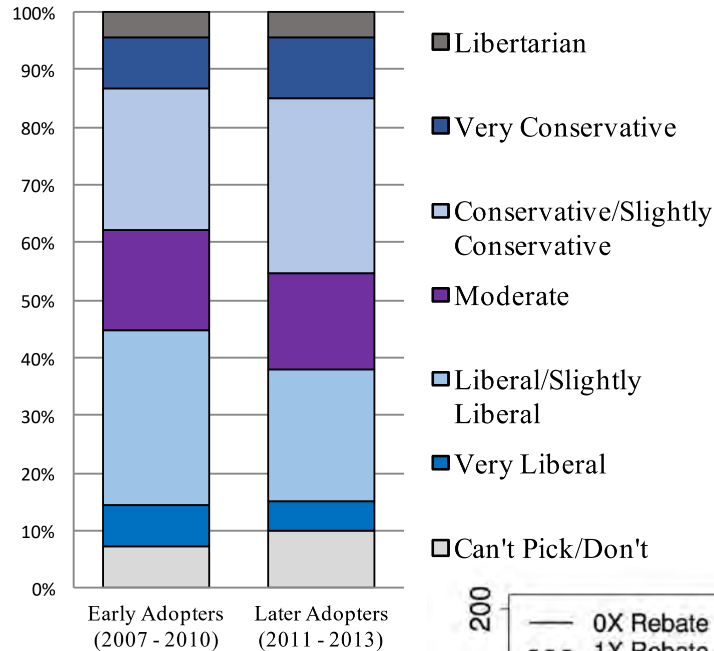
Sandia National Laboratories

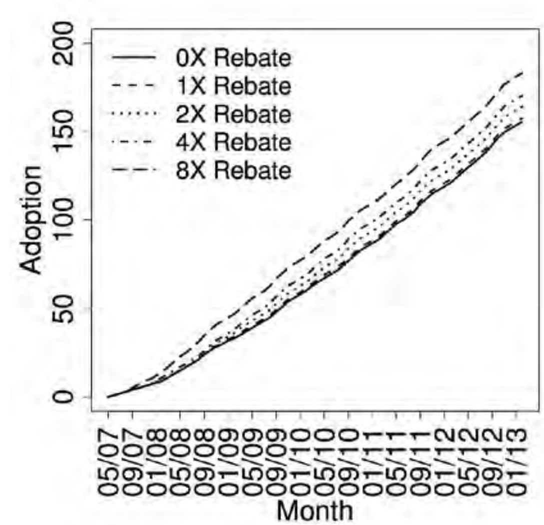
PI: Kiran Lakkaraju

- **The Question:** what are the determinates of residential solar PV adoption trends, at the individual and aggregate levels?

- **Methodology:**
  - ABM
  - Adopter and non-adopter surveys
  - Online pilots regarding information-seeking behavior

- **The Results:**
  - **Conservative shift** in political values of the “typical CA adopter”
  - Economic incentives have **weak impact** yet economics are **driving factor**
  - *Reduction* for liberals, *production* for conservatives





Influence of Novel Strategies in Promoting the Diffusion of Solar PV

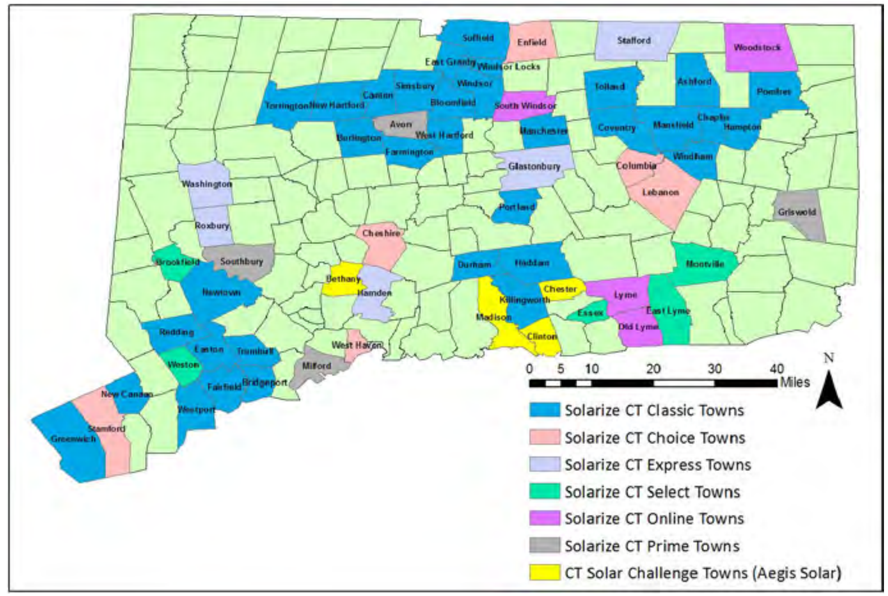
PI: Ken Gillingham

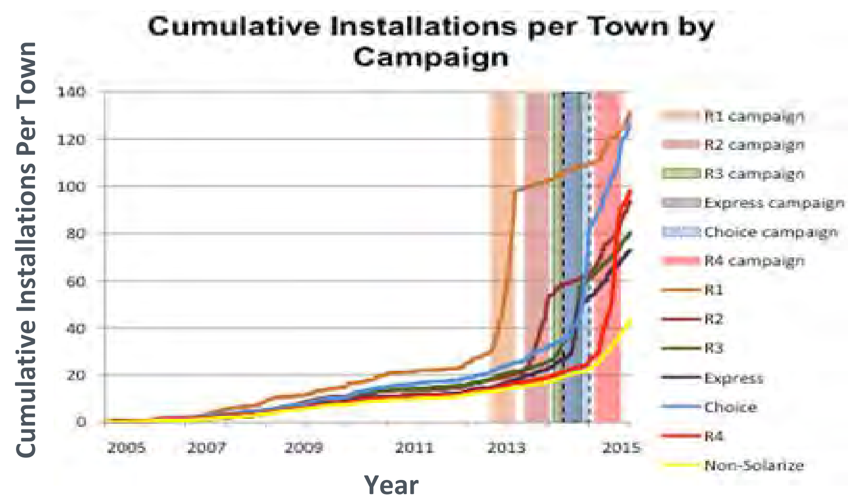
- **The Question:** can the Solarize model create the "hockey stick" of solar diffusion, using CT as exemplar?

- **Methodology:** studying adoption trends of classic and modified variants of Solarize campaigns
  - Town pre-selected installer from competitive bids
  - Group discount pricing
  - Town-supported outreach to potential consumers
  - Limited timeframe to buy in (20 weeks)

- **Variants:**
  - **Express:** 13-week campaign
  - **Choice:** 2-3 installers instead of 1
  - **Prime:** One installer, not competitive, no group discount
  - **Select:** Towns chosen randomly, not RFP process
  - **Online:** Any installer can compete using online portal

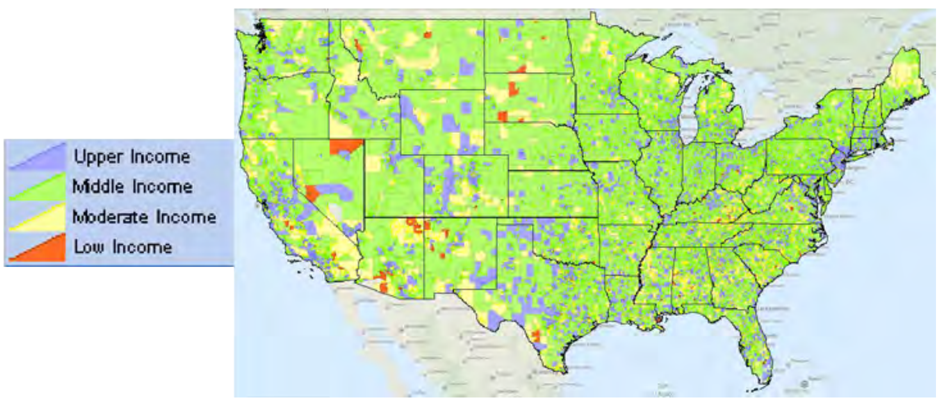
- **The Results:**
  - **Express:** word-of-mouth suffers
  - **Choice:** larger price declines during and after campaign
  - **Prime:** Group pricing **not** essential
  - **Select:** Towns selected **half as effective** vs. applicants
  - **Online:** Facilitates competition





SEEDS 2 – The Adventure Continues!

- Very similar to first round
- More focus on organizational/institutional decision-making
- Also focus on Low and Moderate Income (LMI) individual and community adoption patterns



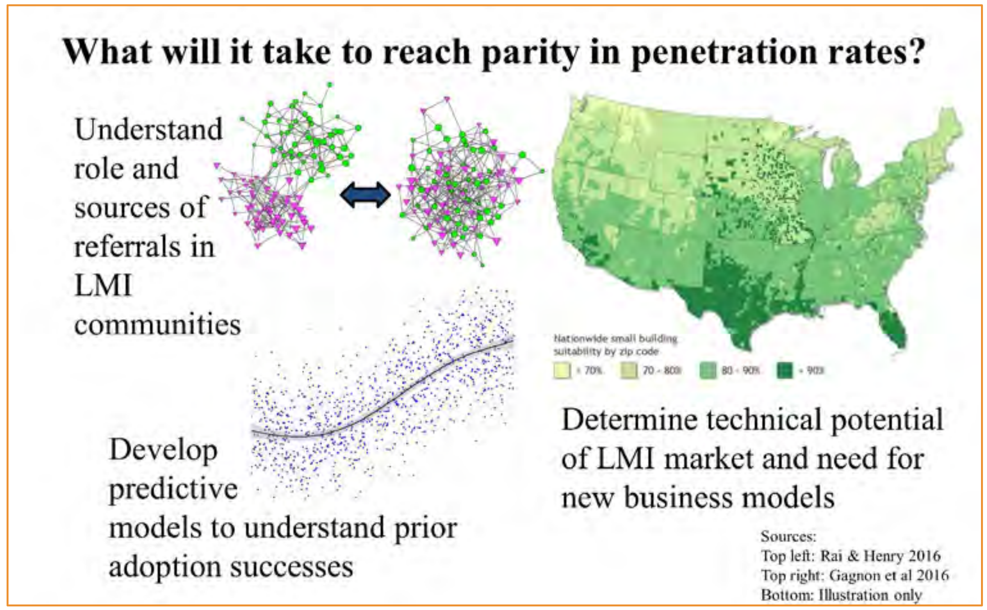
Low- and Moderate-Income Individuals

Organizational Decision-Making

Unlocking Widespread Solar Adoption: Understanding Preferences of LMI Households to Create Scalable, Sustainable Models

PI: Ben Sigrin

- **The Question:** what is required for LMI solar penetration parity?
- **Methodology:**
  - National-level sociodemographic overlay on solar potential
  - Predictive modeling utilizing historical LMI solar installation records
  - Pilot different referral strategies to determine impact on adoption propensity
- **Project Impact:**
  - Determine unique referral patterns and lower acquisition costs
  - Identify need for non-standard ownership models
  - Identify large-scale trends in market adoption barriers and enablers



Modeling Administrative Choices Regarding Streamlined Solar Permitting

PI: Margaret Taylor

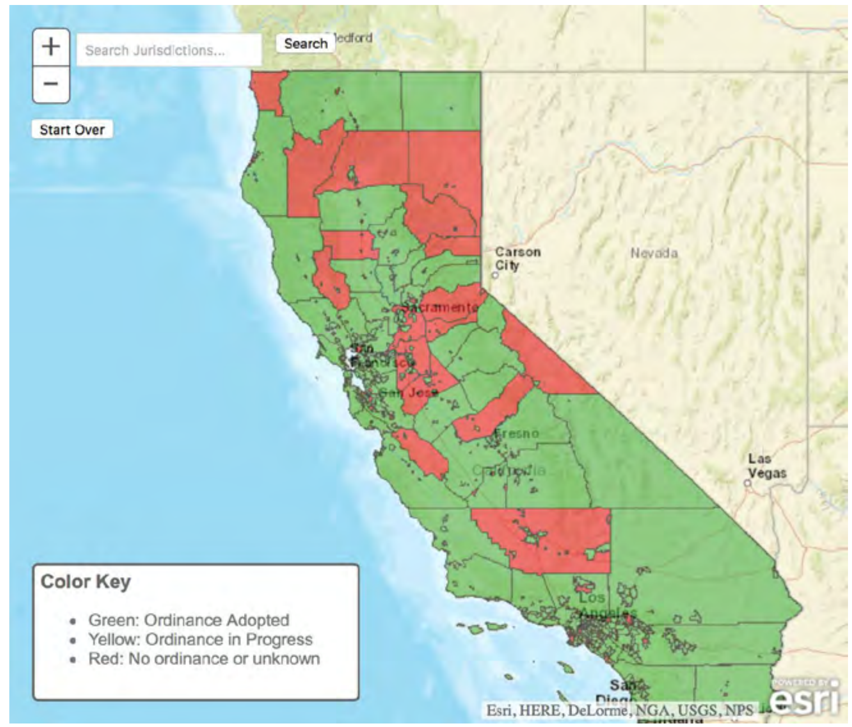
Center for Sustainable Energy

BERKELEY LAB
Lawrence Berkeley National Laboratory

- **The Question:** what factors have caused a large portion of CA AHJs to not adopt Streamlined Solar Permitting?

- **Methodology:**
  - Hybrid open-ended interviews and discrete choice analyses
  - GIS analysis of jurisdictional characteristics

- **Project Impact:**
  - Tool that can be used for creating a scientifically-designed SSP product
  - Significantly higher degrees of adoption of SSP, leading to lowered solar costs



Source: Center for Sustainable Energy

Data-Driven Understanding of Low-to-Moderate Income Customers' Adoption and Financial Qualification in Community Solar

- **The Question:** Is FICO score the only/best option to determine someone's ability to pay for community solar?

- **Methodology:**
  - Financial Modeling based on Utility, Telecom and other related expenses
  - Development partners for model validation
  - Tracking repayment behavior for model refinement

- **Project Impact:**
  - **De-risking LMI participation** in community solar, a requirement and potential barrier in widespread adoption
  - Actual deployment in LMI communities
  - Paradigm shift in evaluating credit & finance as related to energy behavior

EnergyScore developed

4-6 pilot sites secured

~500 LMI households enrolled in shared solar

SOLSTICE INITIATIVE

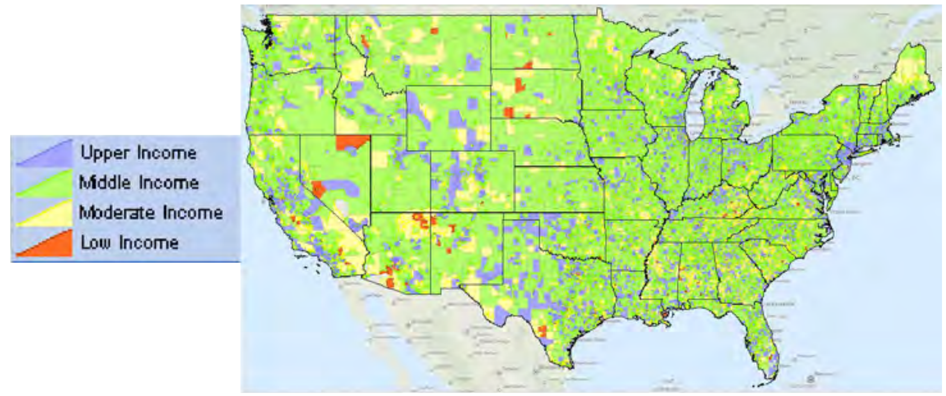
Co-PIs: Sandhya Murali & Steph Speirs

Influence of Novel Strategies in Promoting the Diffusion of Solar PV

- **The Question:** What are the drivers of solar deployment in LMI and grid-congested communities and can they be leveraged?

- **Methodology:**
  - Group discount pricing / shared solar business models
  - Town-supported outreach to potential consumers (CT, NY, SC)
  - ABM and grid-supply modeling

- **Project Impact:**
  - **Increasing LMI participation** in rooftop and community solar, a requirement and potential barrier in widespread adoption
  - Actual deployment in LMI communities across **three states**.
  - **Guidance on best practices for sales in grid congested areas**, critical for future DG-heavy future planning.



PI: Ken Gillingham

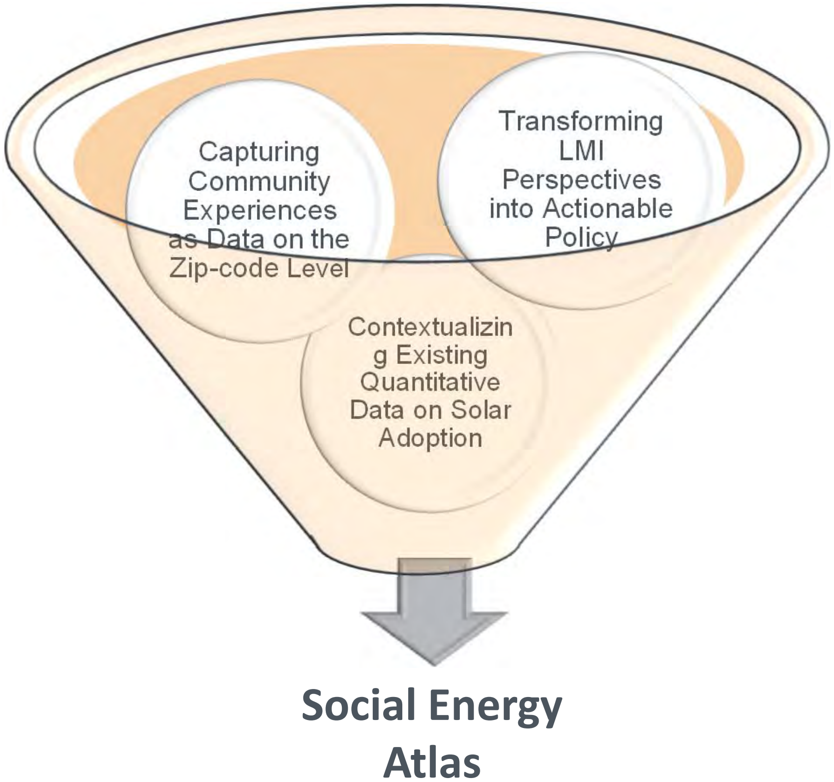
Advancing Solar Innovation of Low and Moderate Income Households: Analysis of American Experiences

PI: Jacqueline Hettel

- **The Question:** What are the non-economic factors affecting solar adoption in LMI households where solar technical potential is highest? What are the key social and economic benefits (or lack thereof) perceived by these households?

- **Methodology:**
  - Extensive aggregation of solar adoption data across AZ.
  - Extensive behavioral choice surveying across AZ, MS, AR, GA including crowd-sourced information
  - sampling protocols and preservation standards pioneered by the Linguistic Atlas Projects.

- **Project Impact:**
  - Building a comprehensive web-based open access platform - the "Social Energy Atlas"
  - The public can contribute to the conversation through a public-facing portal by providing their own solar stories (**effectively crowd-sourcing these data**)



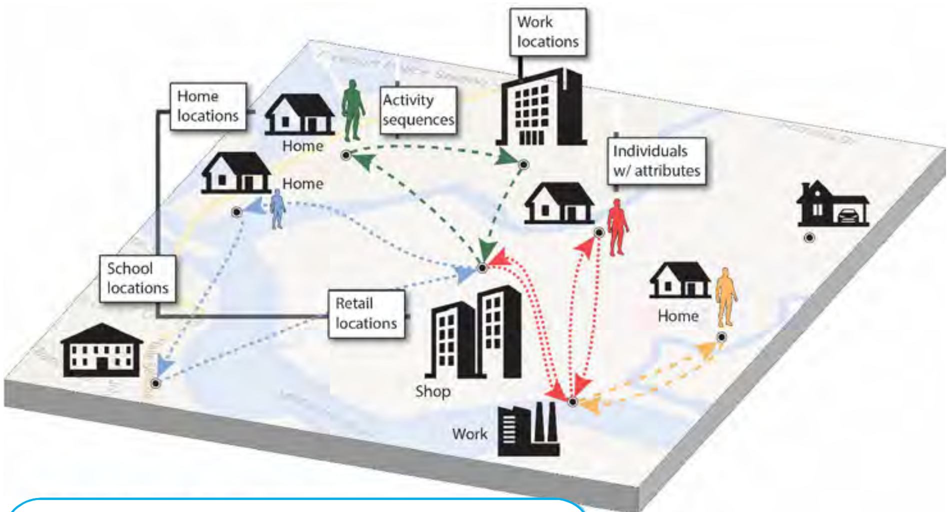
Coupled Social and Infrastructure Approaches for Enhancing Solar Energy Adoption

- **The Question:** are there unique barriers to solar adoption in rural areas?

- **Methodology:**
  - Combining synthetic population data, including power usage, with Agent-Based Models
  - Modeling peer effects in adoption using ABM

- **Project Impact:**
  - Providing maximal economic and non-economic value of solar to rural populations
  - Pushing the boundaries of ABM through incorporation of synthetic populations and peer effects

PI: Achla Marathe



SYNTHETIC POPULATION

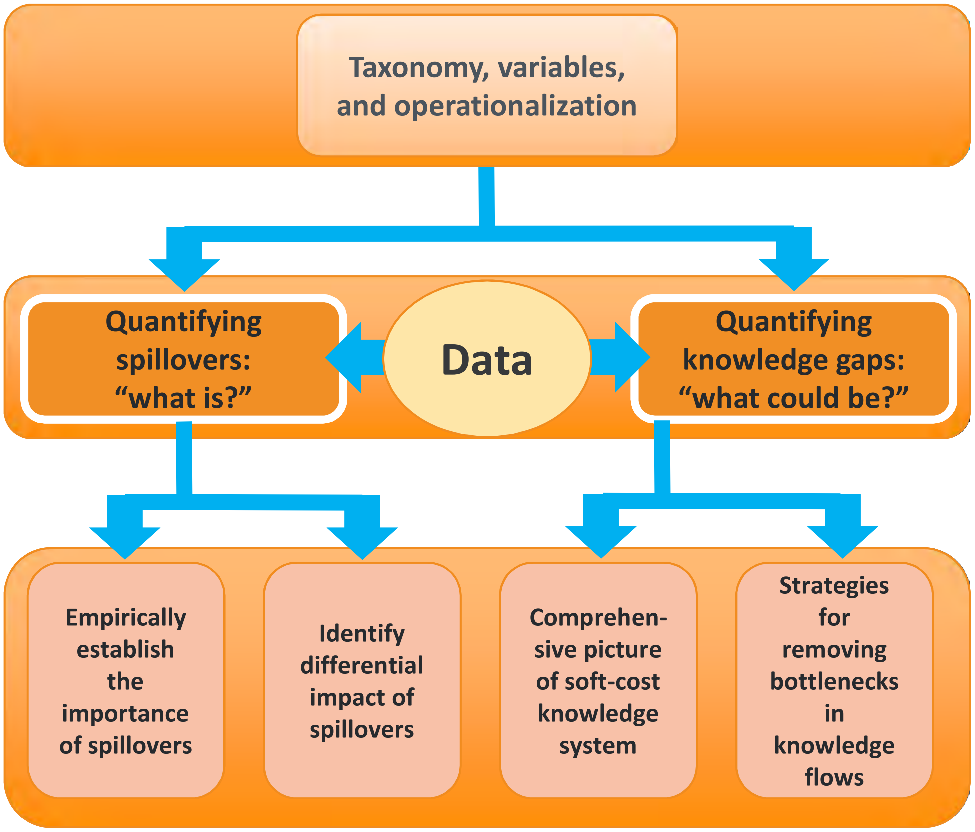
Demographic information, population densities, activity surveys, and other data sources fused by modeling to construct a representation of the actual population and people's interactions.

Knowledge Spillovers and Cost Reductions in Solar Soft Costs

THE UNIVERSITY OF TEXAS AT AUSTIN

PI: Varun Rai

- **The Question:** What is the size and mechanism of knowledge spillovers in the solar industry, both utility-scale and rooftop solar?
- **Methodology:**
  - Comprehensive, multi-method, and data-driven approach
  - Archival research, expert interviews, case studies, surveys, patent analysis, and network analysis.
- **Project Impact:**
  - Project results will comprehensively **address the knowledge system around soft costs**, an important and complex problem area that lies at the heart of future reductions in PV installed costs
  - **Provide policy guidance on the mechanisms of knowledge spillovers in order to leverage streamlining** non-hardware related barriers to solar deployment.



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http://energy.gov/eere/sunshot/solar-energy-evolution-and-diffusion-studies

SunShot Initiative, Solar Energy Technologies Office

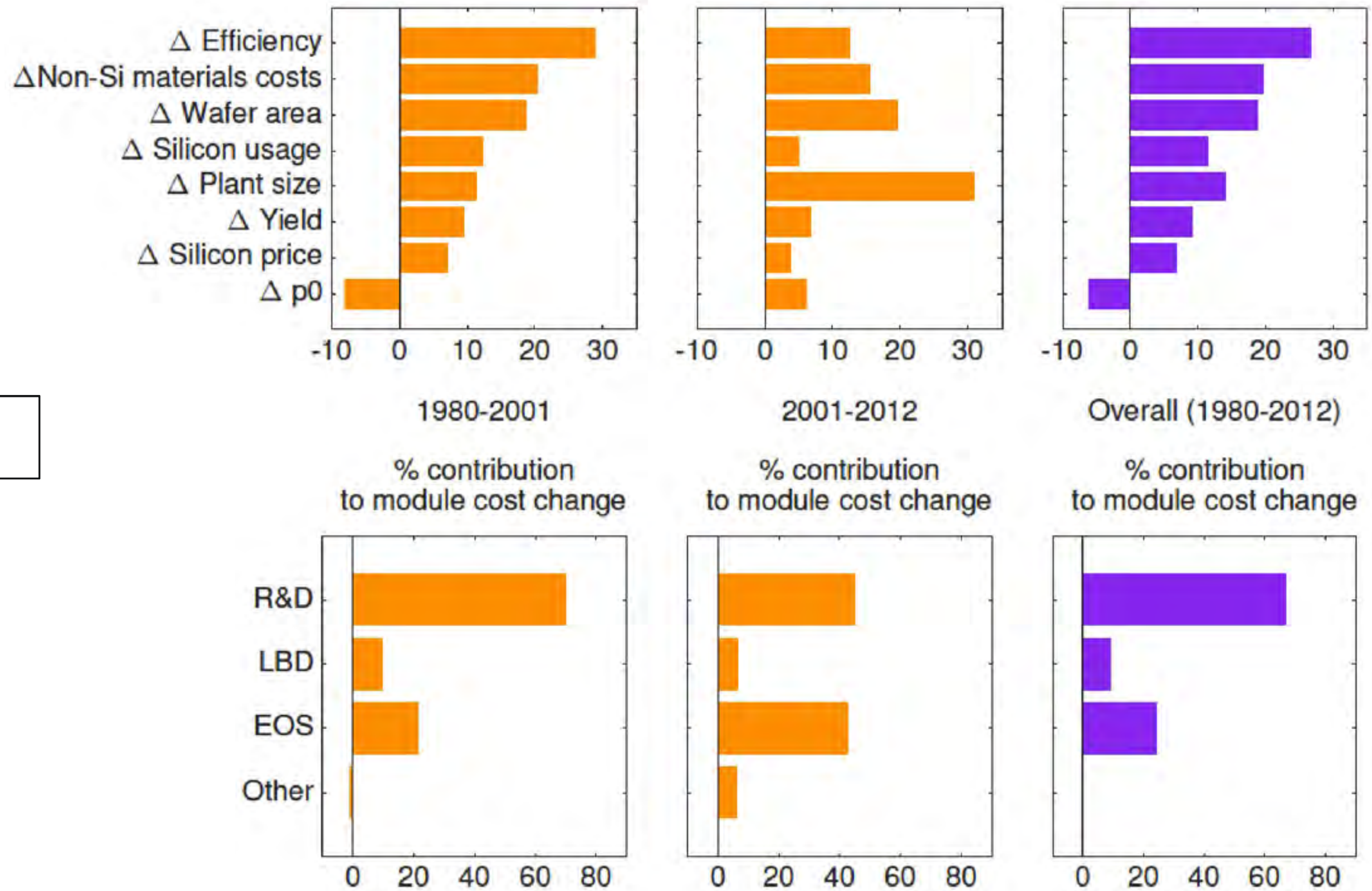
What drives PV solar costs down?

Massachusetts Institute of Technology

Low-Level Cost Drivers

High-Level Cost Drivers

PI: Jessika Trancik

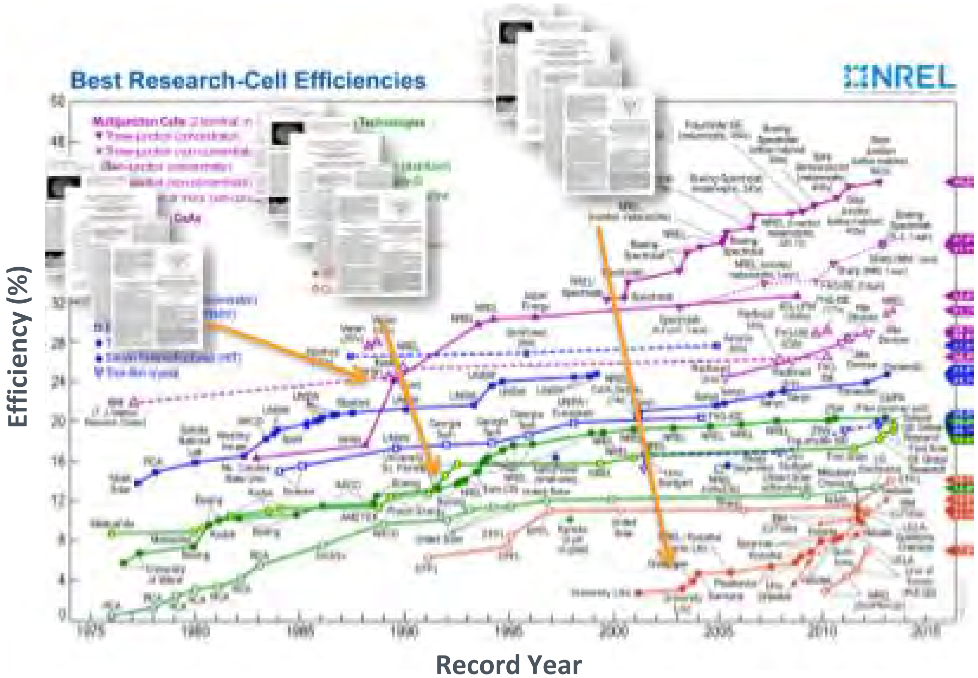


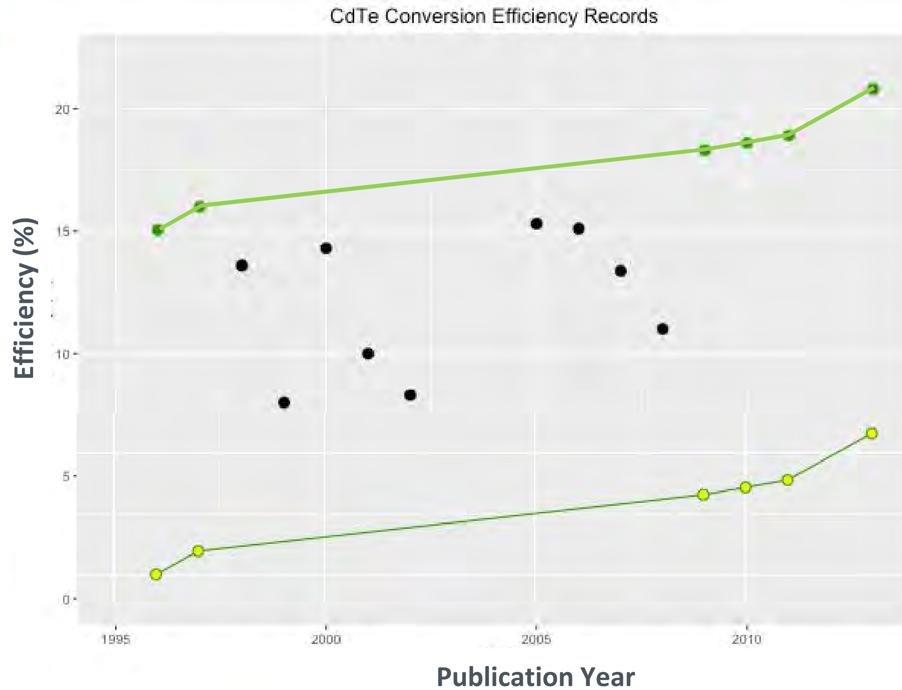
References:
Kavlak G, McNerney J, Trancik JE, Evaluating the changing causes of PV cost reduction, 2016, in preparation

McNerney J, Trancik JE, Scale economies in photovoltaic systems, 2016, in preparation

- **The Question:** Can we explain market trends over time for PV?

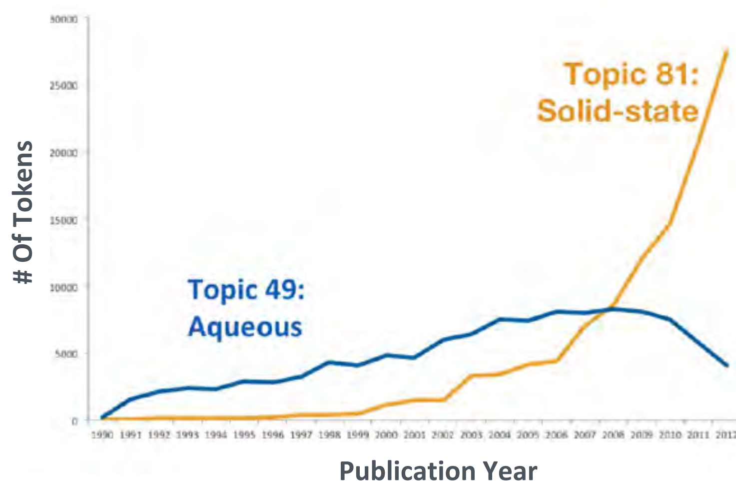
Helios: Understanding Solar Evolution Through Text Analytics





PI: Lucien Randazzese

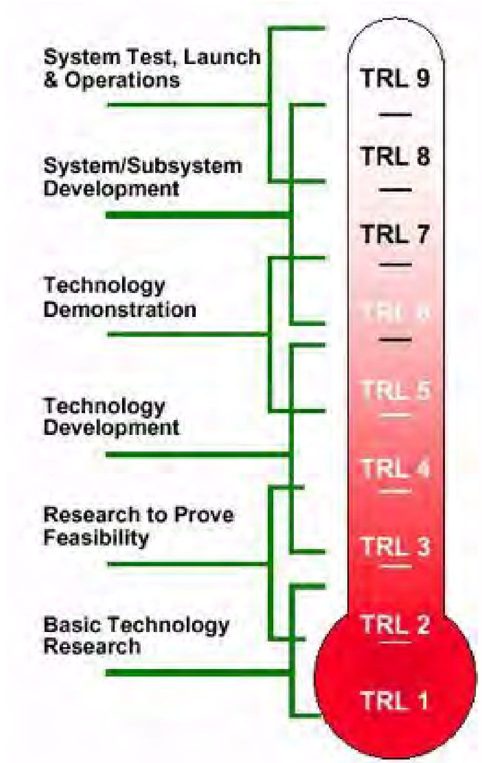
- **The Question:** Can machine learning and text analytics be used to map technological innovation?



Machine Learning for Solar Technology Portfolio Management

PI: Christina Freyman

- **The Question:** can TRLs be determined objectively and reproducibly?
- **Methodology:**
  - Machine learning and text analytics of large corpora of documents
  - Identify unique solar technology maturity parameters for tracking
- **Project Impact:**
  - Allow for consistent rating of tech maturity
  - Provide path to prediction of future tech advances



Subjective TRLs → Objective TRLs

Source: NASA

Modeling PV Innovation and Deployment Dynamics

- **The Question:** how have PV balance-of-systems costs trended over time and what are the causes of these trends?

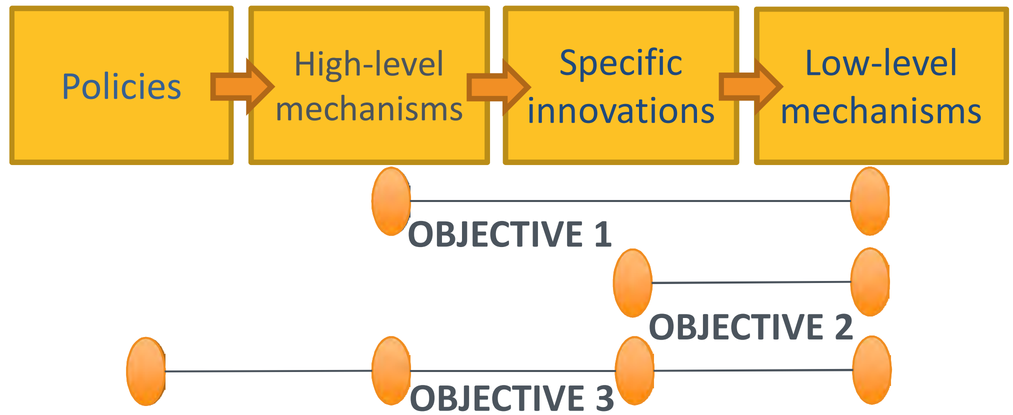
- **Methodology:**
  - Apply mathematical framework from SEEDS 1 to entire PV system costs (beyond the module)
  - Expert elicitation regarding specific tech innovations
  - Survey of RD&D policies in relevant timeframe

- **Project Impact:**
  - Provide boundaries on future cost declines
  - Establish correlational strength of different policies and tech innovations to cost trends

PI: Jessika Trancik

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Massachusetts Institute of Technology



Examples:

Public R&D funding e.g. DOE SunShot's portfolio →	R&D (public actors) →	Improved semi-conductor processing →	Increased module efficiency
Policies supporting deployment e.g. RPS, ITC →	Learning-by-doing →	Streamlined assembly →	Increased yield
→	R&D (private actors) →	Micro-inverters for BOS →	Lower labor costs